National Aeronautics and Space Administration

Technology Transfer and Partnership Office's

Accomplishments Summary | 2007

for NASA Glenn Research Center

07 summary

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Woodrow Whitlow, Jr., Director
NASA Glenn Research Center

The primary mission of the NASA Glenn Research Center (GRC) is to develop critical space flight systems and technologies to advance the exploration of our solar system and beyond, while maintaining our leadership in aeronautics. We are committed to making positive contributions to the public and have adopted a set of strategic goals that include becoming an integral part of the Ohio community and the nation. The Center's Technology Transfer and Partnership Office (TTPO) plays a critical role in achieving this goal, and its 2007 accomplishments are summarized in this booklet. I am proud of their accomplishments and encourage you to take a few moments to review these important contributions.

Woodrow Whitlow, Jr., Director

NASA Glenn Research Center

Kathleen K. Needham, Chief, Technology Transfer and Partnership Office

The vision of the TTPO to leverage the Center's outstanding capabilities and accomplishments and maximize the value extracted from innovations to enhance NASA missions and the U. S. economy clearly complements the goals of GRC. The broad range of services provided by TTPO is summarized on page 1 and services are implemented by a cross-discipline team focused on both infusing externally developed technologies into NASA and spinning out NASA-developed technologies.

This document summarizes some of the more significant partnerships and licenses negotiated by the office in 2007—all of which have the potential to produce amazing products and results for both NASA and the nation.

We are proud of what we have accomplished and we look forward to building on the success of the highly qualified people that make up GRC as we continue to expand our efforts to optimize the value of their innovative and creative work.

Kathleen K. Needham, Chief

Technology Transfer and Partnership Office

NASA Glenn Research Center

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About the TTPO

The Technology Transfer and Partnership Office (TTPO) exists to promote leveraged partnerships. We facilitate and catalyze efforts to ensure that NASA's technology and capability portfolio is supplemented through partnerships with commercial, academic, and other external sectors to gain access to a wider variety of technologies than the Agency could develop in-house.

We enable leveraged partnerships through the wide variety of mechanisms that are illustrated in this report and summarized below.

Plum Brook Station recently hosted the TTPO staff on a tour through its major facilities, including the newly rededicated Space Power Facility.

- **NASA's Innovative Partnerships Program (IPP)**: The IPP promotes technology transfer including licensing, Partnership Seed Fund collaborations, and dual-use partnership development; Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs; and IP management including new technology reporting.
- **Business practices that support and document partnership formation**: The TTPO negotiates Space Act Agreements—NASA's unique method of documenting collaborative activities—as well as prepares GRC's annual *R&T Report*, which documents the most illustrious research achievements of the Center (see page 9).
- **Awards**: Recognition is achieved with the Inventions and Contributions Board Space Act awards for significant contributions to NASA's activities from GRC's engineering and scientific community and through commercial recognition such as the R&D 100 Awards (see page 7). ■

Current GRC Projects

Current GRC projects include

- Development of the Orion Service Module
- Modification of the Space Power Facility for future NASA testing
- Design, construction, and delivery of the Ares 1 Upper Stage Simulator
- Delivery of the Traveling Wave Tube Assembly for the Advanced Capabilities Program's Lunar Reconnaissance Orbiter
- Completion of integration testing of the NASA Evolutionary Xenon Thruster (NEXT) ion propulsion system
- Continuing development of advanced tools and technologies for the next generation of aircraft engines ■

Licensing

Endevco Corporation Licenses Three GRC Patents to Create New Pressure Sensors for High-Temperature and Harsh Environments

Endevco Corporation licensed three silicon carbide (SiC) microelectromechanical systems (MEMS) patents that will enable it to jump start a new line of high-temperature, harsh-environment pressure sensors. NASA will be able to reduce costs and save development time by purchasing Endevco's finished product for use in aeronautic, space, and planetary missions.

The technologies include a MEMS packaging technique and chip fabrication methods that were developed by a team led by Dr. Robert Okojie for use in aircraft engine combustion chambers. SiC pressure sensors manufactured using these new processes can be used to improve testing of jet engines, in deep well drilling, and in automobile combustion cylinders.

Developed with support from both the Aviation Safety and the Fundamental Aeronautics Programs of NASA, these sensors are anticipated for use in the Subsonic, Supersonic, and Hypersonic Projects under the Fundamental Aeronautics Program as well as potential future missions to Venus.

"The significant advantages of this innovation are very exciting," said Endevco President Scott Silcock. "We are in the process of transferring the NASA SiC process into our MEMS manufacturing operation in Sunnyvale, with product availability for field testing in high-temperature applications targeted for late 2008. We have also formed partnerships with companies that have an immediate need for this breakthrough technology."

Spinoffs

Spinoff 2007 highlights recent significant research and development activities across NASA and the successful transfer of space program technology to the marketplace. Below are those activities that originated at GRC.

Computational Modeling Develops Ultra-Hard Steel

QuesTek Innovations LLC, of Evanston, Illinois, developed a carburized, martensitic gear steel with an ultra-hard case using a proprietary computational design methodology. QuesTek's gear steel outperforms, by almost 300 percent, current state-of-the-art alloys used for aviation gears in contact fatigue, according to spur gear fatigue testing performed with a spiral bevel or face gear test rig at GRC's Mechanical Components Branch. Uses for this new class of steel are limitless in areas needing exceptional strength for high-throughput applications.

Deicing System Protects General Aviation Aircraft

Kelly Aerospace Thermal Systems LLC, located in Willoughby, Ohio, collaborated with GRC scientists on deicing technology with assistance from the SBIR program. This collaboration, combined with earlier work, contributed to the development of a lightweight, easy-to-install, reliable wing and tail deicing system called Thermawing; a direct-current (dc)-powered air conditioner for single-engine aircraft called Thermacool; and high-output alternators to run them both.

Design Application Creates 2–D Graphics From 3-D Surfaces

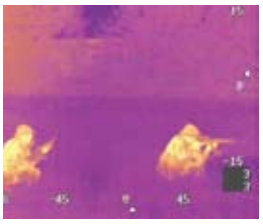
A GRC-developed flattening process that translates a model's surface geometry to a two-dimensional (2–D) template has given Fabric Images, Inc., of Elgin, Illinois, a competitive edge. Specializing in the printing and manufacturing of fabric tension architecture for the retail, museum, and exhibit/trade show communities, the company utilizes the software to translate 2–D graphics for three-dimensional (3–D) surfaces. This process has cut production time by nearly 12 percent per project, reduced wasted material, and enabled the company to offer new design services.

Thermoelectric Devices Advance Thermal Management

United States Thermoelectric Consortium (USTC), of Chico, California, has found technical research from GRC to be a valuable resource for its line of thermal management solutions. In cooperation with NASA, USTC built a gas emissions analyzer for combustion research, which precipitated hydrocarbon particles, preventing contamination that would hinder precise rocket fuel analysis. USTC work has since provided thermal solutions for computer, radar, laser, microwave, and other systems.

Spinoffs *(continued)*

Infrared Imaging Sharpens View in Critical Situations



Innovative Engineering and Consulting Infrared Systems, of Cleveland, Ohio, worked with electrical and optical engineers from GRC's Diagnostics and Data Systems Branch to develop a commercial infrared imaging system that could differentiate the intensity of heat sources better than other systems. The research resulted in the NightStalkIR and IntrudIR Alert Systems, now being used abroad to locate personnel stranded in emergency situations and also to protect high-value operations. The company is also applying its thermal imaging techniques to medical and pharmaceutical products.

Corrosive Gas Restores Artwork, Promises Myriad Applications

NASA research on corrosion and long-duration coatings has led to several alternate applications for atomic oxygen. GRC researchers found that atomic oxygen removed organic compounds high in carbon (such as soot) from fire-damaged artworks without altering the paint color. By oxidizing primarily hydrogen, carbon, and hydrocarbon polymers at surface levels, atomic oxygen can also be used to remove bacterial contaminants from surgical implants (see ICB Exceptional Cases, page 9) and to detect forgeries. Collaborations between the Cleveland Clinic Foundation and the GRC team have also shown it can improve cell adhesion, which is important for the development of new drugs.

Thin, Light, Flexible Heaters Save Time and Energy

EGC Enterprises Inc., of Chardon, Ohio, used GRC's Icing Research Tunnel to develop a thermoelectric thin-film heater technology to address in-flight icing on aircraft wings. Working with GRC researchers and the original equipment manufacturers of aircraft parts, the company developed the Q•Foil Rapid Response Thin-Film Heater. The product meets all criteria for in-flight use and promises a broad range of applications, including cooking griddles, small cabinet heaters, and several laboratory uses.

Food Supplement Reduces Fat, Improves Flavor

Working with GRC, Diversified Services Corporation, of Cleveland, Ohio, developed a nutritional fat replacement and flavor enhancement product called Nutrigras that costs less than the food it replaces and helps manufacturers reduce material costs. The now-commercialized substitute is primarily intended for use as a partial replacement for animal fat in beef patties and other high-fat meat products but can also be used in soups, sauces, bakery items, and desserts. The company is repaying NASA for its help by contributing to food for astronauts on the International Space Station (ISS) using the Nutrigras fat substitute as a flavor enhancer and shelf-life extender. ■

GRC Spinoffs Lead to Over 200 Products

The editor of *Spinoff*, Daniel P. Lockney, has recently reported that GRC has contributed core technologies to over 200 products and processes born from the Center's aeronautics and space research.

Closer to home for GRC, *Spinoff* has tracked the progress of over 60 Ohio companies whose products have benefited from collaboration with NASA. ■

Visit http://www.sti.nasa.gov/tto/ for more information

Collaboration:
2007 IPP Seed Fund Winners

The IPP Partnership Seed Fund is an initiative to enhance NASA's ability to meet missions' technology goals by providing seed funding to address barriers and initiate cost-shared, joint-development partnerships.

The following 6 GRC projects were selected out of 38 partnership awards. IPP is contributing $1.5 million, with an additional $2 million of industry effort, and $3.8 million in NASA program funding, for a total value of $7.3 million in support of these projects.

Space Act Agreements

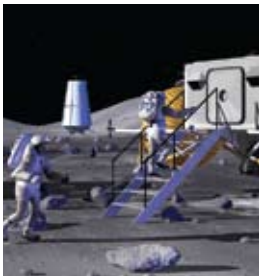
Space Act Agreements can greatly benefit the advancement of research and development efforts. These flexible arrangements allow NASA to work cooperatively with industry and academia in either a reimbursable or nonreimbursable structure. In 2007, GRC signed 95 Space Act Agreements valued at over $10.5M with aerospace companies, universities, and other government agencies. ■

Bringing Moon Tire Technology to Earth

Goodyear Tire and Rubber Company, Akron, Ohio

Researchers at GRC and Goodyear are collaborating to understand the types of lunar and Earth vehicles that could use the wire mesh, airless/rubberless tires developed in the 1960s for the Apollo Lunar Roving Vehicle. The project includes the modeling, building, and testing of several prototypes toward future exploration of the Moon as well as Earth-based passenger vehicles.

Producing Life Support and Propulsion System Consumables for Lunar and Planetary Outposts



Northern Centre for Advanced Technology, Inc. (NORCAT), Sudbury, Ontario, Canada

This collaboration between GRC and the NORCAT will result in technology approaches for "mining" native resources on lunar and planetary surfaces to produce mission consumables, such as oxygen and water, to dramatically reduce the mass, risk, and cost of extended-duration missions.

Low-Density Turbine Blade Superalloys to Improve Engine Performance and Reduce Emissions

Honeywell Aerospace, Phoenix, Arizona

The GRC project team is partnering with Honeywell Aerospace to scale up a new NASA-patented blade alloy that meets or exceeds performance of current alloys with significantly reduced density, improved performance, reduced fuel burn, and reduced emissions for subsonic aircraft.

Reducing Aircraft Noise With Foam-Metal Acoustic Liner

Williams International, Walled Lake, Michigan

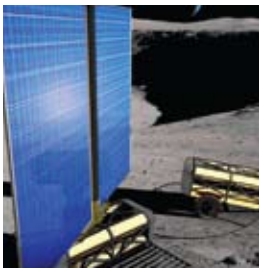
A small, business jet-class turbofan engine will be supplied by Williams to allow NASA to test the use of foam-metal liners in close proximity to the rotor with the goal of achieving a significant reduction in aircraft noise.

Developing Cross-Linked Aerogel (X-Aerogel) Blanket Insulation

Parker Hannifin, Cleveland, Ohio; Aspen Aerogels, Northborough, Mass

Researchers at GRC are working with Parker Hannifin and Massachusetts-based Aspen Aerogels to advance a NASA-developed technology for cross-linking aerogel composites with polymers. The resulting material could be used in thermal and acoustic insulation as well as in lightweight, damage-resistant multifunctional structures for aircraft, space suits, cryogenic storage tanks, and other aeronautic and space applications (see ICB Exceptional Cases, page 8).

Space Power System Pallet for Demonstrating Fuel Cells, Lithium-Ion Batteries, and Advanced Thermal Management Technologies



The Boeing Company, Huntington Beach, California; Teledyne Energy Systems, Inc., Hunt Valley, Maryland; Center for Space Power, College Station, Texas

To meet mission requirements for advanced energy storage systems and thermal management approaches, this team is designing a space power systems pallet that incorporates an advanced proton exchange membrane fuel cell, a lithium-ion battery with an advanced charge control management system, and advanced thermal technologies. It will be used to space-validate critical technologies under development. ■

An Update on 2006 Seed Fund Winners

Alternative Fuels for Next-Generation Combustor Applications Completes Successful Initial Tests

Pratt & Whitney

IPP participation enabled the NASA Subsonic Fixed Wing Program to expand their test program of the Pratt & Whitney ultra-high bypass ratio engine to include the impact of using a 50/50 blend of Fischer-Tropsch fuel. The emissions and performance results are currently being analyzed, but the testing has demonstrated, for the first time, that a 50/50 blend of Fischer-Tropsch fuels can run in advanced engines with no combustor or fuel-compatibility issues.

New Lithium-Ion Batteries With Enhanced Safety and Power Density for Future NASA and Aerospace Missions

Jet Propulson Laboratory, A123 Technologies, ABSL Space Products and Northrup Grumman Space Technology

Extensive tests of the A123 Technologies commercial-off-the-shelf, high-power, lithium-ion cell technology have corroborated their superior cell-level safety attributes and high-rate performance, which are relevant in addressing potential future NASA exploration mission needs. Improvements have also been made to the low-temperature performance of the baseline cell chemistry. ■

Small Business: The SBIR/STTR Programs

Four SBIR Companies Receive Additional NASA Funding

GRC SBIR/STTR Programs Lead in Success Stories

The IPP seeks solutions to many of NASA's technical challenges by funding SBIR and STTR projects. GRC has continuously been at the forefront of NASA in both the number of SBIR awards and capturing the most success stories.

ZIN Technologies Building Subject Load Device for ISS Second Treadmill

GRC is providing Phase 3 funding from the Human Research Program (HRP) to Cleveland company ZIN Technologies to build a flight version of a novel passive pneumatic subject load device (PP–SLD) being designed under a Phase 2 SBIR from Johnson Space Center (JSC). The work is part of the second International Space Station treadmill project (ISS T2) that will help enable an increase in the number of crew on ISS. The PP–SLD has been identified as a useful risk mitigation technology that tethers the crew member to the treadmill during microgravity and provides adjustable loading during exercise sessions for improved musculoskeletal health. This development is a good example of leveraging SBIR funds to directly meet the needs of programmatic missions.

A&P Technology Develops Affordable Composite Fan Cases With Damage-Tolerant Braided Fiber Architecture

With an SBIR contract from GRC, A&P Technology, Inc., of Cincinnati, Ohio, has developed an approach to manufacturing affordable composite fan cases with a damage-tolerant braided fiber architecture to contain failed fan blades in aircraft engines. A&P Technology developed this technology through partnerships with Williams International and Honeywell International and sponsorship with General Electric Aircraft Engines. This new, low-cost manufacturing process reduces the weight of the largest structure in a high-bypass aircraft engine by more than 30 percent and is recognized as one of the most promising emerging technologies in the nation. Two Phase 3 contracts worth a total of $775K will fund the exploration of further improvements in the design, moving it closer to Federal Aviation Administration certification.

WebCore Technologies Develops Lightweight Composite Fan Cases

Collaborating with the U.S. Air Force, the U.S. Navy, and several aircraft engine manufacturers, WebCore Technologies of Miamisburg, Ohio, developed a reliable, damage-tolerant structural sandwich core material for "softwall" jet engine fan containment systems. With Phase 2 SBIR funding, the company has produced a case 25 to 50 percent lighter than titanium and aluminum monolithic cases yet retains twice the mechanical properties after subscale projectile impact tests.

Sunpower, Inc., Develops High-Efficiency, Long-Life, Low-Mass Stirling Engine for Low-Power Applications

In a collaborative effort supported in part by a Phase 3 SBIR contract, Sunpower, Inc., of Athens, Ohio, has developed the Advanced Stirling Converter, a critical element of Lockheed Martin's Advanced Stirling Radioisotope Generator, which produces four times the electric power per kilogram of Plutonium-238 than traditional radioisotope thermoelectric generators. Since solar power arrays have limits in size and distance from the Sun, this power source will become critical for outer planetary and deep-space exploration and will enable lower cost space missions. ■

Innovation: Creating Value Through Research

New Technologies Reported: 121

Patents Issued: 9

Patent Applications Filed: 15

Recognition: 2007 Awards

R&D 100 Awards

R&D 100 Awards recognize products as the most innovative ideas of the year. Winners in 2007 were

High-Speed Electro-Mechanical Shutter for Imaging Spectrographs

Dr. Quang-Viet Nguyen of GRC's Combustion Branch developed a high-speed electro-mechanical shutter for imaging spectrographs using electronically synchronized slotted wheels to gate pulses of light at durations as short as 10 millionths of a second. These computer simulations are critical tools used to design and build cleaner burning and more fuel efficient aircraft engines.

Defect Clustering Thermal and Environmental Barrier Coatings for Si-Based Ceramic Turbine Engine Components

Drs. Dongming Zhu, Robert Miller, and Narottam Bansal of GRC's Structures and Materials Division, developed multilayered, multifunctional coating systems that incorporate several revolutionary technologies that greatly extend the material temperature capability, environmental stability, and high heat-flux durability of lightweight Si-based engine components in combustion environments.

Antenna Near-Field Probe Station Scanner

Dr. Afroz Zaman, Dr. Richard Lee, Dr. Felix Miranda, and Phillip Barr (Purdue University) of the Antenna, Microwave and Optical Systems Branch; Dr. Kevin Lambert, Analex Corporation; and William Darby, R&D Labs Technical Branch developed this scanner that measures radiation patterns of miniature antennas fabricated on any dielectric substrate as well as semiconductor wafers. It can also test antennas embedded in circuits with active devices.

100 R&D 100 Awards

2007 marked the receipt of GRC's 100th R&D 100 Award. Past and current winners of this prestigious honor—called the "Oscars of Innovation" by the *Chicago Tribune*—gathered to celebrate with Center management on Feb. 4, 2008.

Congratulations were also offered by Ohio Governor Ted Strickland and Ohio Lt. Governor Lee Fisher as well as by U.S. Senator George Voinovich and Congressman Dennis Kucinich. ■

Inventions and Contributions Board (ICB) Space Act Awards

NASA's ICB recognized through the Space Act Award process 178 GRC employees for significant contributions in science and technology to aeronautics and space activities. ICB awards totaled $124,050 and included

- 4 Exceptional Space Act Awards
- 9 additional Space Act Awards
- 97 *NASA Tech Briefs* awards
- 25 patent application awards

Outstanding Innovation

TTPO strives to leverage GRC's outstanding capabilities and accomplishments for maximum benefit to NASA and the U.S. economy.

ICB Exceptional Cases

Of the more than 3000 awards given in 2007, the ICB selected 12 exceptional cases of the most significant value. Four GRC innovations were selected to be part of that elite group. As ICB puts it, "These innovations may power the future."

Polymer Cross-Linked Aerogels (X-Aerogels): A New Class of Strong, Lightweight Materials

Innovators: Maryann Meador, Nick Leventis, James Johnston, Eve Fabrizio, Faisal Ilhan

Dr. Maryann Meador, co-inventor of X-Aerogels, in her laboratory at Glenn Research Center

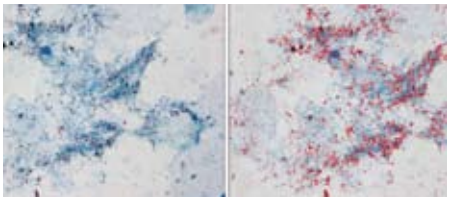
X-Aerogels are a new class of strong, lightweight materials derived by applying a conformal polymer coating onto the skeletal framework of an aerogel. With only a nominal increase in density (a factor of two or three), X-Aerogels can be as much as 300 times stronger than the underlying inorganic framework. This new technology offers tremendous potential in a variety of uses by simply varying the surface chemistry of the nanoparticles, the chemical identity of the polymer, and the chemical identity of the inorganic backbone itself (see Seed Fund, page 5).

A Compact Microscope Imaging System (CMIS) With Intelligent Controls

Innovator: Mark McDowell

Dr. Mark McDowell, inventor of CMIS, in his laboratory at Glenn Research Center

The CMIS is a diagnostic microscope analysis tool that combines intelligent image processing with remote-control capabilities usually seen only in conventional microscopes. Its autofocus feature automatically scans an image and performs machine vision analysis on multiple samples simultaneously. The hardware requires less room than conventional microscopes and the system can remotely and automatically run, control, and analyze microscope experiments. The CMIS has tremendous external potential with applications in automated inline inspection of precision parts, biomedical imaging, fingerprint identification, remote examination of soil/water samples, automated blood/cell analysis, and several areas of microscopy.



Cancer cells highlighted with the CMIS and its related software for diagnostics

Non-Invasive Polarimetric-Based Glucose Sensor

Dr. Rafat Ansari tests his glucose sensor invention

Innovator: Rafat R. Ansari

Dr. Rafat Ansari's optoelectronic apparatus non-invasively measures the concentration of glucose in the human body. By performing polarimetric and interferometric measurements of the human eye, the device acquires data that can be used to compute the concentration of glucose in the aqueous humor. With the concentration of glucose being of significant importance to human health, there could be a large potential market for instruments based on this apparatus. Further efforts in miniaturizing the system using fiber optics may result in a portable glucose sensor in the not-too-distant future.

Atomic Oxygen Removal of Biologically Active Contaminants From the Surfaces of Orthopaedic Implants to Minimize Inflammation

Innovators: Eric B. Banks, Michael Banks, Bruce A. Banks, Sharon K. Miller

Dr. Eric Banks, Dr. Michael Banks, Bruce Banks, and Sharon Miller, co-inventors

The technology behind this innovation was developed while working on low Earth orbital atomic oxygen interactions with spacecraft materials. This spinoff application is a process for removing biologically active contaminants from the surfaces of orthopaedic implants. Seventy-five percent of orthopaedic implants are contaminated with endotoxins, which cannot be removed with sterilization and often lead to joint loosening and implant failure. Exposing the implant surfaces to atomic oxygen, however, removes all endotoxins and minimizes chances of inflammation in the patient after surgery (see Spinoffs, page 3). ■

Glenn R&T Report

The annual *Glenn Research and Technology (R&T) Report* provides a summary of outstanding research and technology accomplishments this year. Each report contains 100 to 200 short articles submitted by the technical staff and is organized by major technology areas. Available on the Web, this is one of GRC's most popular publications, receiving over 5 million hits per year.

See http://www.grc.nasa.gov/WWW/RT/ for more information. ■

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